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Military FM 3-3
Herbicides

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FIELD MANUAL

TACTICAL EMPLOYMENT OF HERBICIDES

HEADQUARTERS, DEPARTMENT OF THE ARMY

DECEMBER 1971

FOR TRAINING DEPARTMENT USE

FOREWORD

This manual provides information for use in planning herbicide operations at division, brigade, and lower levels. It contains a discussion of advantages that can be obtained by employing herbicides in tactical situations. The physical and chemical properties of agents ORANGE, BLUE, and WHITE are presented with information on agent handling and disposal methods. The manual also discusses air and ground dissemination systems, conditions influencing the effectiveness of herbicides, and guidance for command and control of herbicide operations. Information is presented on the downwind drift hazards produced by the A/A45Y-1, PAU-7/B, and AGRINAUTICS spray systems. A conversion chart and a glossary of terms are included at the end of the publication.

FIELD MANUAL
No. 3–3

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., *14 December 1971*

TACTICAL EMPLOYMENT OF HERBICIDES

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* This manual supersedes Chapter 5 of TC 3–16, 9 April 1969.

CHAPTER 1

INTRODUCTION

1-1. Purpose

The purpose of this manual is to provide doctrinal guidance for the tactical employment of herbicides at division, brigade, and lower levels.

1-2. Scope

This manual discusses technical and operational factors governing the use of herbicides in military operations. It also presents—

a. Physical and chemical properties of agents ORANGE, BLUE, and WHITE and information on storage, handling, and methods of disposal.

b. Information on air and ground dissemination systems.

c. Conditions influencing the effectiveness of herbicides.

d. Guidance for command and control of herbicide operations.

1-3. Tactical Employment of Herbicides

Defoliation of heavily vegetated areas by the use of herbicides is the primary means of obtaining visual observation of enemy forces, facilities, roads, ambush sites, infiltration routes, and other enemy locations from the air, ground, or water.

a. The use of herbicides for defoliation—

(1) *Enhances security.* Defoliation of vegetation bordering and overhanging roads, paths, trails, waterways, and railroads enhances security around friendly base camps, airfields, ammunition dumps, ports, along railroads, waterways, and other locations by providing defensive fields of fire and reducing possible ambush sites.

(2) *Improves military intelligence.* Defoliation of large-area targets improves military intelligence for plans and operations by increasing vertical and horizontal visibility in heavily forested or dense jungle areas. Defoliation also provides data for correcting existing maps and for preparing new ones.

(3) *Reduces enemy resistance.* In defoliated areas, troops will meet less enemy resistance than in areas that have not been defoliated and fewer troops will be required for an operation. Exposure of the enemy's supply depots, base camps, and other locations will make him more vulnerable to air strikes and the resultant damage, harrassment, and threat of attack may cause him to move out of an area.

(4) *Increases troops available for combat and reduces casualties.* Defoliation of broad defensive fields of fire around friendly base camps and locations, and defoliation of possible ambush sites permits commanders to reduce the number of men required for base camp security and convoy guard work and makes more troops available for combat duty. Improved fields of fire—*wherever located*—act as a deterrent to enemy attack and help to reduce friendly casualties when the enemy does attack.

(5) *Facilitates movement of military supplies.* Defoliation along highways, railroads, and main shipping channels will facilitate movement of supplies and decrease the number of convoy guards required.

b. Herbicides can also be used to reduce the enemy's food and industrial crops. This could cause him to—

(1) Divert combat manpower to production of food.

(2) Depend on local food resources.

(3) Become more stationary because of the necessity to cultivate hidden crops.

(4) Reduce production of war munitions.

1-4. Changes and Comments

Users of this publication are encouraged to submit recommended changes and comments to improve the publication. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons will be provided for each comment to insure understanding and complete evaluation. Comments should be prepared using DA Form 2028 (Recommended Changes to Publications) and forwarded direct to the Commanding Officer, US Army Combat Developments Command Chemical-Biological-Radiological Agency, ATTN: CDCCBR-DP, Fort McClellan, Alabama 36201.

CHAPTER 2

HERBICIDE AGENTS

2–1. General

a. Herbicides are chemical compounds used to kill or damage plants (AR 310–25). They can be used to dry foliage or to stimulate or inhibit growth by modifying physiological processes in plants. These chemicals are classified as contact herbicides or as systemic herbicides, depending on the way they affect plants.

(1) *Contact herbicides.* Contact herbicides (or desiccants) are used to damage plant tissue by local action at the point of application and show little or no movement throughout the plant. For this reason, thorough spray coverage is essential for maximum agent effect. After being sprayed with a contact herbicide, susceptible plants dry rapidly; this causes leaves to fall from some plant species, and to shrivel but remain on others.

(2) *Systemic herbicides.* Systemic herbicides are absorbed at the point of application and moved by the sap stream to other parts of the plant. These chemicals are growth regulators and usually act slower than contact herbicides. They damage plants by both local and systemic action, causing leaves to fall and, finally, killing the plants when the dose has been adequate. Plants treated with sublethal doses frequently recover partially or completely. Some plant species are highly resistant to this class of chemicals and show very little outward change. Systemic herbicides are most effective on woody plants and broad-leaved vegetation in an active state of growth.

Note. Even though herbicides cause leaves, plants, and grasses to turn brown, leaves will remain on some trees and plants, and grasses will still stand. Therefore, to obtain maximum visibility, plants must be burned, cut, or removed by other means, such as bulldozer or labor force.

b. Various commercial chemical compounds used as herbicides have been adapted for use in military operations. Authority to use these chemicals must be obtained through the proper channels as explained in chapter 4. Herbicides described below are nicknamed ORANGE, BLUE, and WHITE to correspond with identifying color bands used on the shipping drums and for convenience.

2–2. ORANGE

a. Composition. A 50:50 mixture of:

2,4-D (n-butyl-2,4-dichlorophenoxyacetate)
and
2,4,5-T (n-butyl-2,4,5-trichlorophenoxyacetate)

b. Physical and Chemical Properties.

Physical state	Liquid at room temperature
Color	Reddish brown
Solubility	Soluble in diesel fuel and organic solvents; insoluble in water
Freezing point	45°F to 46°F
Weight	10.7 pounds/gallon
Effect on materials:	
Metal	Noncorrosive
Paint	Harmful to some
Natural rubber	Harmful
Neoprene	Harmful
Teflon, Viton	Resistant
Polyethylene	Resistant
Butyl rubber	Resistant

c. Physiological Properties.

(1) ORANGE is a systemic herbicide that defoliates a wide variety of woody and broad-leaved herbaceous plants. It affects grasses, bamboos, and similar plants less. Agent ORANGE is absorbed by a plant at the point of application within a few hours, and the chemical is translocated.

(2) The components of ORANGE are rapidly decomposed by soil microorganisms and the chemical usually disappears from soils within 1 to 3 months following application. Lateral distribution of the agent due to volatility alone is negligible.

(3) ORANGE is low in toxicity to man, fish, and wildlife; but it will cause slight skin irritation and minor inhalation effects.

d. Defoliation Capability. ORANGE will defoliate adequately forest vegetation in temperate

and tropical regions. See paragraph 3–4 for recommended application rates. Treated grasses and bamboos may exhibit brown foliage and partial top-kill, but they recover rapidly. The typical response of tropical, woody vegetation to systemic defoliants is progressive. For example, ORANGE applied during the growing season causes—

- hardwood foliage to discolor in 1 or 2 weeks,
- leaves to dry in 2 or 3 weeks, and
- leaves to begin to fall after 4 weeks.

Depending upon the type and density of vegetation, overall defoliation after 1 month averages about 50 percent and ranges from 15 to 90 percent. Defoliation increases and reaches its maximum during the second or third month in a single-layered canopy or during the fourth month in a dense, multilayered canopy. Satisfactory levels persist for 3 to 12 months in a single-layered canopy but for only 1 to 3½ months in a multilayered canopy. Thereafter, regrowth and replacement vegetation from ground cover may reduce effectiveness of the original treatment. Therefore, retreatment is desirable in dense-cover areas to extend the period of defoliation.

e. Anticrop Capability. ORANGE is effective in the control of most broad-leaved crops when applied at the rate of 1 gallon per acre. Annual crops that can be killed by ORANGE when applied at any growth stage include:

Beans	Melon	Sesame
Cabbage	Peanuts	Soybeans
Cotton	Pepper	Tobacco
Gourd	Ramie	Watermelon
Jute		

Root or tuber crops that show the greatest reduction in yields when ORANGE is applied during early growth stages include:

Manioc or cassava	Taro
Potatoes	Yams
Sweet potatoes	

Perennial and woody crop species vary widely in their response to direct applications of ORANGE. Crops highly susceptible to herbicide damage are:

Jackfruit	Papaya
Kapok	Star apple or caimito

Moderately susceptible crops are:

Banana	Mango	Pomelo
Castor bean	Mulberry	Roseapple
Guava	Pineapple	Tea

Citrus and rubber plants can be defoliated by ORANGE when the agent is applied in quantities greater than 1 gallon per acre. However, the trees will usually refoliate within several months. Coconut and betel palms are more resistant to ORANGE than citrus and rubber plants.

2–3. BLUE

a. Composition. Agent BLUE currently in use is a commercial, liquid formulation of sodium cacodylate called Phytar 560G.

b. Physical and Chemical Properties.

Physical state	Free-flowing liquid
Color	Reddish or brownish
Solubility	Soluble in water and alcohol; insoluble in oils
Freezing point	−22°F
Weight	11.0 pounds/gallon
Effect on materials:	
Metals:	
Uncoated mild steel (soft malleable)	Rapid initial reaction; gray precipitate formed
Zinc	Rapid chemical reaction and color change; heavy granular precipitate formed
Aluminum	Slight initial reaction; white precipitate formed
Brass	No initial reaction; white precipitate formed
Copper	No initial reaction; no solid precipitate formed
Tin	No initial reaction; gray suspension formed

No significant effect on paint, natural rubber, neoprene, Teflon, Viton, polyethylene, or butyl rubber.

c. Physiological Properties.

(1) BLUE is a fast-acting contact herbicide that is effective against broad-leaved herbaceous or woody plants or grassy vegetation. It causes rapid browning and drying with accompanying shriveling and falling of leaves in some woody species. BLUE is exceedingly effective in the top-kill of grassy plants to include perennials during any season. At rates of application used for defoliation (para 3–4), the chemical exhibits little or no systemic action within the plant.

(2) In contact with soil, BLUE is quickly deactivated by surface absorption; it is nonvolatile and is not affected by light.

(3) This agents is readily absorbed through the skin, and prolonged absorption may cause a distinct garlic odor on the breath. BLUE has a very low toxicity to animals.

d. Defoliant Capability. When applied to susceptible vegetation at the recommended application rate (para 3–4), noticeable browning or discoloration is evident in 1 day and maximum defoliation usually occurs in 2 to 4 weeks. How-

ever, the desired level of defoliation is of relatively short duration when compared to that of systemic agents. In dense forests with multilayered canopies, applications of BLUE can be repeated in 2 to 4 weeks after the initial treatment to insure penetration to lower vegetation layers and to extend the period of defoliation. Regrowth of some perennial grasses, such as elephant grass, wild cane, or cogon grass, is likely to occur within 1 to 2 months after treatment. This necessitates repeated spray applications.

e. Anticrop Capability. BLUE is the agent of choice for destruction of cereal and grain crops. Effects of the chemical become evident within 12 to 24 hours, and plants die within a few days. Since BLUE is water-soluble, it should not be applied during rain or when rain is predicted.

2-4. WHITE (Tordon 101)

a. Composition.

20 percent picloram (4-amino-3,5,6-trichloropicolinic acid) and
80 percent 2,4-D, both in the form of triisopropanolamine salts.

b. Physical and Chemical Properties.

Physical state	Viscous liquid
Color	Dark brown
Solubility	Insoluble in oils; active components are soluble in water
Weight	9.6 pounds/gallon
Weight of active ingredients (as acid equivalent):	
Picloram	0.54 pound/gallon
2,4-D	2.0 pounds/gallon
Remainder consists of water, wetting agent, and other inert ingredients	
Effect on materials:	
Metals	Noncorrosive
Other materials used in spray equipment	Noncorrosive

c. Physiological Properties.

(1) WHITE is readily absorbed by foliage and the root system and is quickly transported throughout the plant.

(2) Since soil microorganisms have little effect on the components of WHITE, this agent is more persistent in soils than ORANGE or BLUE and losses from soils occur principally by leaching. In sparsely vegetated areas, when applied at rates used for defoliation, WHITE may persist in soils for as long as 1 year. It is subject to only limited decomposition by sunlight and ultraviolet radiation.

(3) Tests indicate that a single direct exposure to a spray of WHITE of normal concentration would not constitute a percutaneous or inhalation hazard. This chemical is considered nontoxic and not hazardous to humans, animals, or fish.

d. Defoliant Capability. WHITE is effective principally on broad-leaved herbaceous plants and particularly on woody plants. However, effects of the agent develop slowly on woody plants and full defoliation may not occur for several months after spray-application. Temperate zone conifers are also susceptible to WHITE but defoliation is delayed. Most grasses and monocotyledonous plants, including nipa palm, are resistant to WHITE.

e. Anticrop Capability. WHITE is not recommended for use on crops because of its persistence in soils.

CHAPTER 3

CONDITIONS INFLUENCING THE EFFECTIVENESS OF HERBICIDES

3-1. General

Effectiveness of herbicides will be determined by type of vegetation in the target area, herbicide selected for use, the rate of application, and the growth stage of vegetation.

3-2. Target Vegetation

Target vegetation will vary from dense tropical evergreen forests to open forests consisting of both evergreen and deciduous vegetation. Density of forests may range from a single-layer of vegetation to multilayered canopies and may consist of a single plant species or of many species of trees, shrubs, vines, bamboos, or palms. Response to herbicides will vary with the mixtures of species and the complexity of the forest cover. Species differ widely in their response or susceptibility to the systemic herbicides ORANGE and WHITE. The long-term effectiveness of herbicide treatments will be influenced by the proportion of resistant species. Some forest vegetation can be effectively defoliated for 4 to 12 months with a single application of chemical. Repeat applications may be needed to maintain long-term defoliation, particularly in multilayered canopies. Secondary forests or scrub with a single layer may show better canopy penetration and more plant damage than forests with several layers.

3-3. Selection of Herbicide

Information presented below will help analysts select the most efficient agent for use in herbicide operations.

a. WHITE produces a slower initial defoliation response and a slower rate of regrowth than ORANGE. Foliage will become discolored or brown within 2 to 4 weeks after being sprayed with WHITE, and within 1 week after being sprayed with ORANGE.

b. The oil-soluble herbicide, ORANGE, is more effective under moist, rainy conditions than the water-soluble herbicides, WHITE and BLUE. ORANGE is not readily washed off foliage and will penetrate waxy-surfaced leaves more efficiently than the water-soluble herbicides.

c. BLUE is a rapid, short-term defoliant of broad-leaved herbaceous or woody plants or grassy vegetation.

d. ORANGE and WHITE are effective defoliants of broad-leaved, deciduous forests.

e. Evergreen, conifer forests are more susceptible to WHITE than ORANGE.

f. ORANGE is effective primarily against broad-leaved crops but it can also be used to control broad-leaved weeds.

g. BLUE is effective primarly against cereal or grain crops.

h. Most spray missions will be carried out on targets with mixed forest vegetations; however, targets may consist of a single, dominant plant type. Examples and recommended herbicides are:

- Nipa palm, frequently found with mangroves, provides a dense screen along waterways. It can be controlled successfully only by ORANGE, but it responds much more slowly than other vegetation.
- Elephant grass can be controlled by BLUE deposited at high rates.
- Bamboos of various types are difficult to control. Some species may be defoliated by repeated applications of BLUE, but the plants are not killed, and the clumps of stems alone provide effective concealment.
- Broad-leaved, annual crop plants as a target can be treated as a single species since they are uniformly killed by ORANGE applied at rates used for defoliation.

i. Selection of herbicide may be influenced by the proximity of agricultural crops to the target.

3-4. Rate of Application

a. Application rate as used in this manual is

the amount of agent, expressed as gallons per acre (gpa), that must be dispersed to obtain an effective concentration on target vegetation.

Note. To convert gallons per acre to gallons per hectare, simply multiply gpa by 2.5; for example 3.0 gpa × 2.5 = 7.5 gallons per hectare. Appendix B is a conversion chart.

b. Tests with ORANGE at rates of 1.0 to 6.0 gpa showed increased defoliation with higher application rates. Tropical-zone forests with multilayered canopies require 3.0 gpa and temperature-zone forests can be adequately defoliated with 1.0 to 1.5 gpa. Application rates of 1.0 to 1.5 gpa of BLUE or ORANGE on susceptible crops may be sufficient; however, 3.0 gpa will give higher assurance of adequate coverage and results in more rapid onset of effects than 1.0 gpa. Therefore, for general use, an application rate of 3.0 gpa of ORANGE, BLUE, or WHITE is recommended for defoliation missions; and a rate of 3.0 gpa of ORANGE or BLUE is recommended for anticrop operations.

3–5. Growth Stage of Vegetation

The effectiveness of systemic herbicides (plant growth regulators) is influenced by the growth stage of vegetation in the target area. Because such agents depend upon movement of the chemical from the foliage to other parts of the plant, they are most effective when applied to actively growing vegetation. For similar reasons, systemic herbicides are effective against young plants. In tropical areas, plants are dormant during dry seasons when moisture in soils is insufficient for continued active growth; in temperate zones, the same condition results from low temperatures. Therefore, a systemic herbicide applied during the dormant season takes longer to produce a significant response and generally is not as effective as the same concentration applied during the growing season. Contact herbicides normally do not kill perennial woody or herbaceous plants and, in the tropics, new foliage may develop in 30 to 90 days. ORANGE and WHITE are systemic herbicides, BLUE is a contact herbicide.

CHAPTER 4

COMMAND AND CONTROL OF HERBICIDE OPERATIONS

4–1. General

a. National policy will govern the use of herbicides in a theater of operations. When the decision to use these agents has been made, commanders will receive the necessary authority through command channels. Specific guidance for their use will include the level of command that may approve herbicide operations.

b. The employment of herbicides for military purposes must be judiciously controlled. Many unforeseen and undesirable problems may arise unless the user is thoroughly familiar with the socioeconomic and political implications, the type of vegetation to be attacked, the best herbicide to use, and the most efficient mode of dissemination. The user must know which chemicals will produce the desired level of defoliation on vegetation in a particular target area.

c. Close staff coordination and planning are essential to enable the subordinate commander to make the proper decision. A key staff element is the G5/civil military operations section, which performs the dual functions of civil affairs and psychological operations (PSYOP). The civil affairs function includes all activities that might affect the relationship between the military, the civil government, and the people of the area. As for PSYOP, every action taken by the government and its military forces has a psychological impact on the populace and must be considered in all planning activities. PSYOP is an effective tool that can be employed before, during, and after the conduct of military operations. When such operations involve civilians and enemy forces, PSYOP can assist by informing the target population of what can be expected in the area, and of instructions and actions that will minimize structural, crop, and plant damage and nonmilitary casualties. To achieve national objectives, there will be situations where short range tactical advantages and expediencies should be sacrificed in favor of long range goals. For example, firepower must be used with discretion to minimize noncombatant casualties. Employment of herbicides capable of causing widespread crop and plant damage can have a disastrous effect on civilian support and attitudes, post hostility, rehabilitation, and economic recovery.

4–2. Herbicide Operation Request

Written command directives prescribe policies, responsibilities, and procedures governing the operational employment of herbicides. Requests for crop destruction or defoliation are prepared in accordance with these directive by units desiring this support. The following information should be included in these requests:

a. Overlays or annotated photographs depicting the exact area. Figure 4–1 is an example overlay.

b. Target list.

(1) Description of the area (to include the district, county, state, section, province, or other political subdivision).

(2) UTM grid coordinates.

(3) Length and width or area of the target. This may be expressed in meters, acres, or hectares.

(4) Type of vegetation crop (to include planting and harvest times for crops).

(5) Recommended herbicide.

(6) Recommended delivery system.

c. Enemy situation in and near the target area.

d. Location of food crops or other vegetation that the user of herbicides does not want damaged or destroyed.

e. Psychological operations considerations. For information on psychological operations, techniques, and procedures, see FM 33–5.

f. Civil affairs considerations: direct impact on human and animal users of products of plants to be damaged or destroyed and indirect impacts on commerce, fishing, transportation, and other economic aspects of communities affected; and actions to be taken during and after proposed

TARGET OVERLAY: DEFOLIATION REQUEST NO. ONE TARGETS NO: 1 & 2
REFERENCE: MAP, SOUTH VIETNAM, 1:50,000, SHEET 5000, 5010

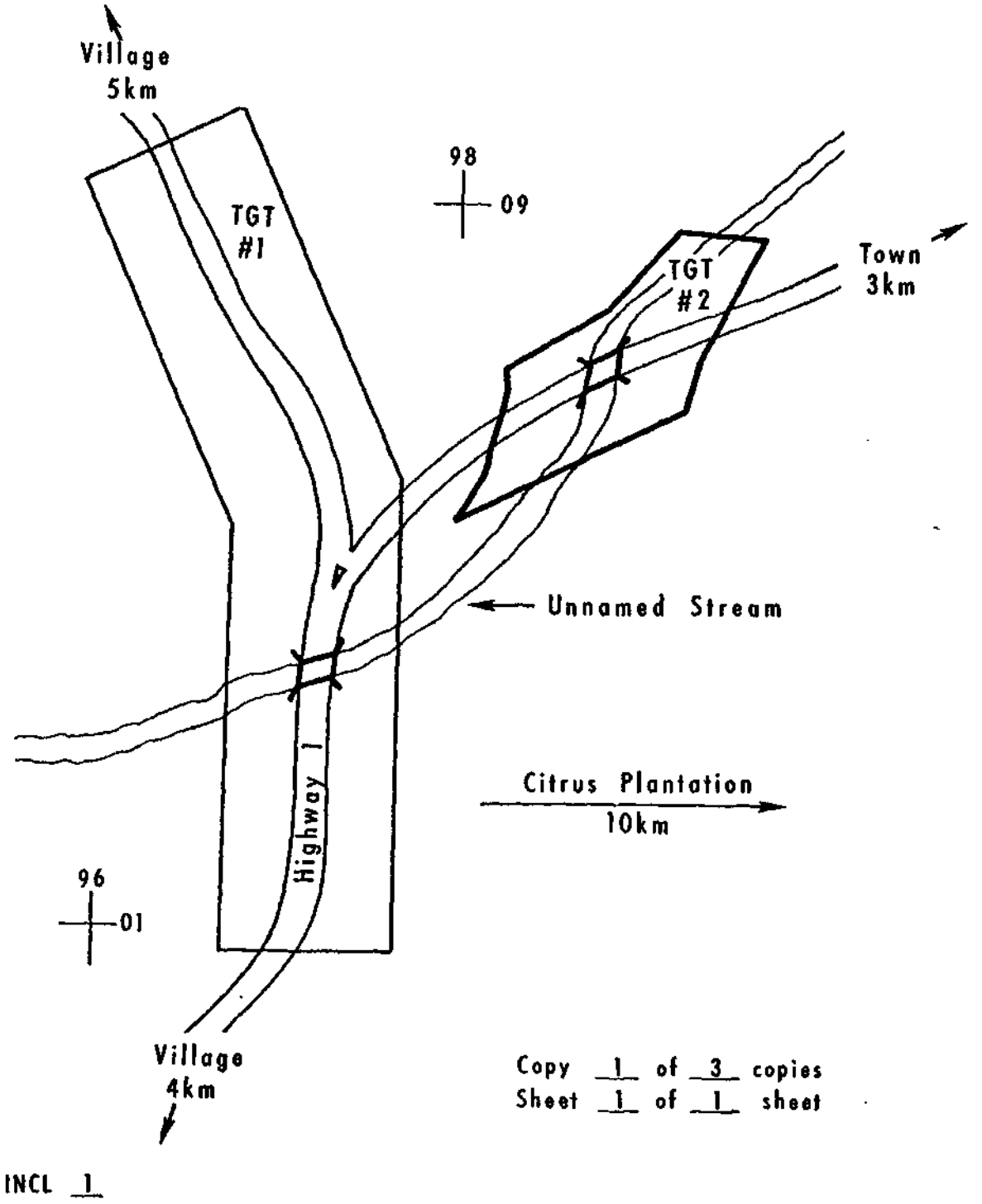


Figure 4–1. Example target overlay.

herbicide operations. The command civil affairs staff officer or the commander of the civil affairs unit responsible for the area should participate in this facet of planning because of its complexity. For detailed information on civil affairs, see FM 41–10.

CHAPTER 5

METHODS OF DISSEMINATION

5–1. Aerial Spray Systems

Herbicide operations requiring the use of the A/A45Y–1 or PAU–7/B spray tank must be coordinated with the Air Force Liaison Officer.

a. A/A45Y–1 Internal Defoliant Dispenser.

(1) *Status.* Standard, Air Force.

(2) *Description.* The A/A45Y–1 defoliant dispenser (fig. 5–1) is a modular spray system for internal carriage in cargo aircraft. It is used primarily with the C–123 aircraft but can be adapted for use in the C–130. The module consists of a 1,000-gallon tank, a 20-horsepower gasoline engine, and a pump mounted on a frame pallet equipped with removable wheels. A single module is used in the C–123; two such modules can be used in the C–130, and each is operated from a console which incorporates pump and spray release controls. The C–123 system uses wing booms and a tail boom. Each wing boom is 22 feet long and 1.5 inches in diameter with 12 regularly spaced check valve nozzles. These booms extend from the engine nacelles toward the wing tips. The tail boom is 20 feet long and 3 inches in diameter with 4 check valve nozzles spaced at 6-inch intervals on each end. It is anchored in the center of the fuselage near the aft cargo door. During an operational mission, the system's gasoline engine is started. A recirculating line permits the engine-pump combination to be operated without actual dissemination. When the aircraft is over the target, a motor-operated gate valve in the disseminating line is opened so that the agent can flow to the spray nozzles.

(3) *Characteristics.*

Weight of tank (empty)	1,420 pounds
Weight of tank filled with:	
ORANGE	11,585 pounds
BLUE	11,870 pounds
WHITE	10,540 pounds
Agent capacity	950 gallons
Length of tank	151 inches
Cradle width	54 inches
Flow rate	Variable (100 to 285 gallons/minute)

(4) *Area coverage.* Using the following parameters, the A/A45Y–1 can cover a swath about 88 meters by 16 kilometers or 1.4 square kilometers (351 acres).

Aircraft speed	130 knots
Release altitude	150 feet
Flow rate	230 gallons/minute

To achieve predictable deposits of agent, spray missions should be conducted under inversion to neutral atmospheric conditions and calm windspeed. Direction of flight should be into the wind.

(5) *Uses.* The A/A45Y–1 system can be used for defoliation along lines of communication, canals, river channels, boundary zones, and large forested areas where improved visibility is desired. It can also be used to destroy enemy-held crop targets.

b. PAU–7/B Spray Tank.

(1) *Status.* Standard, Air Force.

(2) *Description.* The PAU–7/B tank (fig. 5–2) was designed for external carriage on high performance aircraft. It consists of three stainless steel sections welded together: nose cone, center section, and aft hemisphere. An aluminum tail cone, which houses the electrical components, provides an aerodynamic contour to the tail. Ram air enters through a 2.78-inch diameter butterfly valve near the forward end of the center section and flows through an exit port that uses another 2.78-inch diameter butterfly valve. An aluminum dissemination boom, fitted with flexible, wire-reinforced tubing and extending from the exit port in the aft section of the tank, is lowered 30° below the horizontal before agent is disseminated. The tank has an on-off capability.

(3) *Characteristics.*

Weight of tank (empty)	567 pounds
Weight of tank filled with:	
ORANGE	2283 pounds
BLUE	2331 pounds
WHITE	2106 pounds
Agent capacity	160.4 gallons
Length of tank	185 inches

Diameter of tank	22.5 inches
Flow rate	360 gallons/ minute

(4) *Area coverage.* Using the following parameters, the PAU-7/B can cover a swath about 52 meters by 7.5 kilometers or 0.4 square kilometer (97 acres).

Aircraft speed	550 knots
Release altitude	150 feet
Flow rate	360 gallons/ minute

(5) *Uses.* The PAU-7/B spray system can be used for small-scale defoliation missions, vegetation control in base perimeters, minefields, ammunition dumps, artillery positions, and lines of communication. The system has also been used for small-area crop destruction.

c. AGRINAUTICS Spray System.

(1) *Status.* Not type-classified for herbicides.

(2) *Description.* The AGRINAUTICS (formerly AGAVENCO) spray unit (fig. 5-3) is self-contained and can be used in the Army UH-1B and UH-1D, the US Navy UH-1E, and the US Air Force UH-1F helicopters. It can be installed in, or removed from, the aircraft in a matter of minutes because it is merely "tied down" to installed cargo shackles, and no modifications are required for its use. The sprayer is a commercial item that can be used to disseminate insecticides or herbicides. Essential features are:

- Fiberglass tank (200-gallon)
- Cradle or support structure 10 × 4 × 3.4 feet
- Externally mounted, six-blade windmill pump
- Spray booms, 32 feet long, with positions for 56 nozzles.

(3) *Characteristics.*

Weight of system (empty)	200 pounds

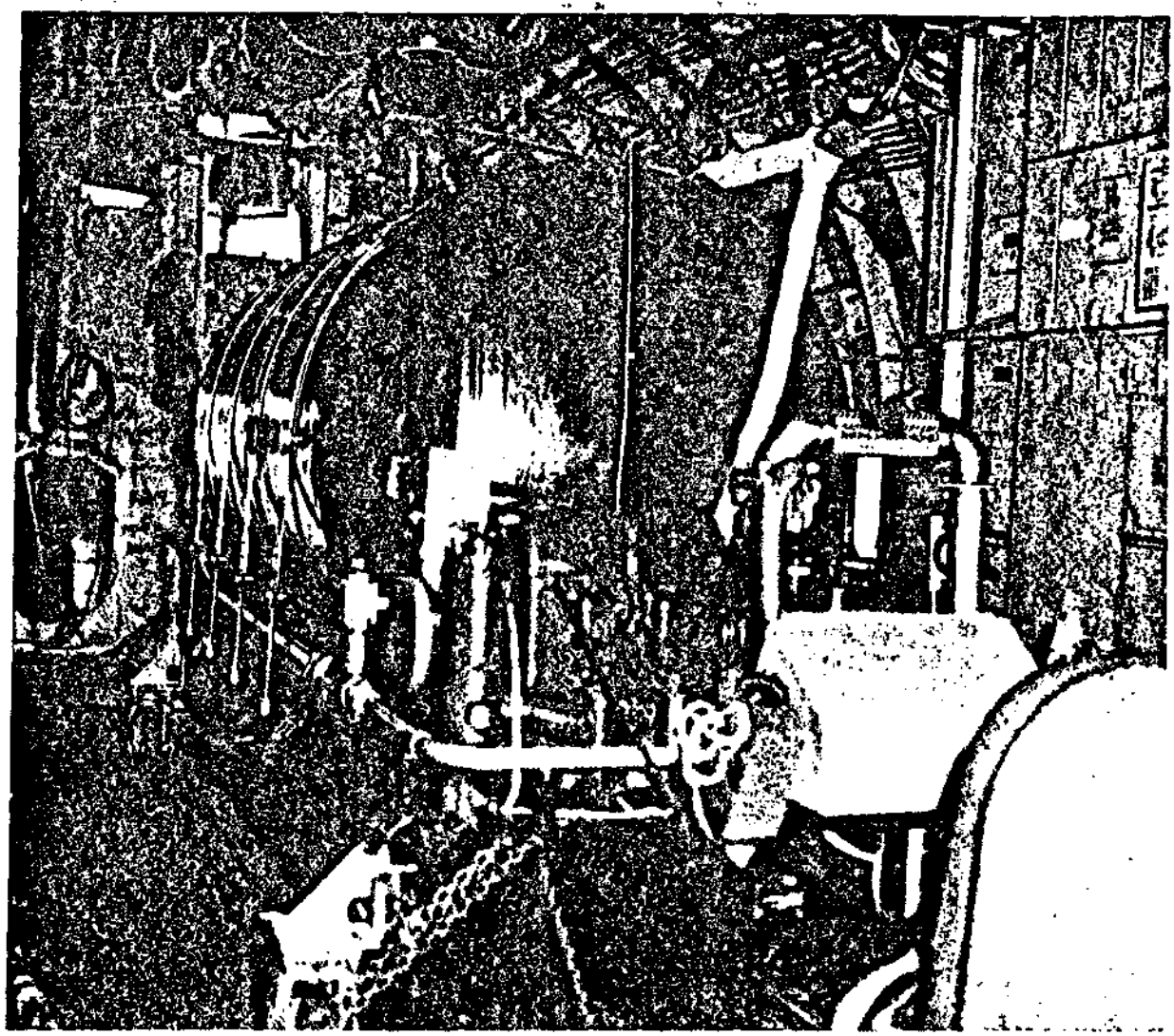


Figure 5-1. A/A45Y-1 internal defoliant dispenser.

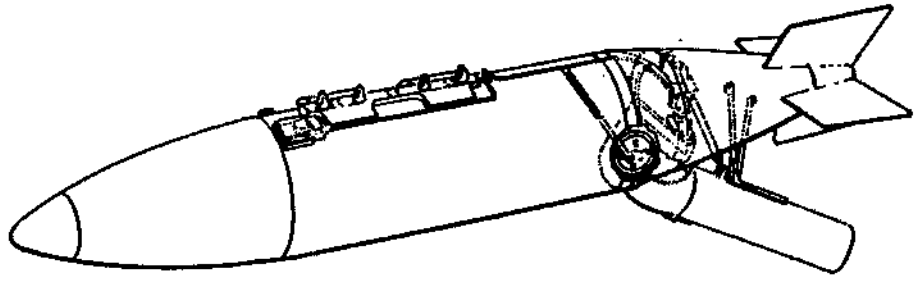


Figure 5–2. PAU–7/B spray tank.

Weight of tank filled with:
- ORANGE ..... 1377 pounds
- BLUE ..... 1410 pounds
- WHITE ..... 1256 pounds

Agent capacity:
- Maximum capacity ..... 195 gallons
- Operating capacity ..... 110 gallons

Maximum flow rate ..... 175 gallons/minute

(4) *Area coverage.* Using the following parameters, the AGRINAUTICS spray system can cover a swath about 30 meters by 1000 meters or 30,000 square meters (7 acres):

Helicopter speed—50 knots
Release altitude—50 feet
Flow rate —175 gallons/minute

Because of the maneuverability of the UH–1-series helicopters, the AGRINAUTICS normally is used on small, irregular targets requiring several passes to achieve complete spray coverage.

(5) *Uses.* The AGRINAUTICS spray system can be used for small-scale defoliation missions, vegetation control in base perimeters, minefields, ammunition dumps, artillery positions, and lines of communication. The system can also be used for small-area crop destruction missions.

d. Field Expedients. A number of field expedient (jerry-rigged) devices have been developed for use in helicopters to spray small areas such as fields of fire around perimeter defensive areas, helicopter landing sites, and crops. These devices range from a 55-gallon drum equipped with spray bar for temporary mounting across the skids of a UH–1B/D helicopter to a 400-gallon metal tank or 500-gallon collapsible fuel bladder with power-driven fuel-transfer pump and improvised boom for use on CH–47 aircraft.

e. Guidelines for Delivering Aerial Spray. The basic consideration in spraying herbicides for vegetation control is to deposit them precisely on the selected target. Exact placement of the spray is essential to secure full advantage of the herbicide and to prevent possible damage to crops or other desirable vegetation near the target. The following guidelines have been developed for the A/A45Y–1 systems:

(1) Missions should be accomplished under inversion or neutral atmospheric conditions with air temperature not to exceed 85°F if possible. These conditions usually occur in early morning hours. Spraying under lapse conditions will result in upward movement of fine drops with consequent drift and reduction of deposit.

(2) Winds should not exceed 10 knots at ground level.

(3) Spray should be released at altitudes of 200 feet or less.

(4) The spray should be coarse to reduce the proportion of small drops that may drift off target. (Mass median diameter (MMD) of spray—300 to 350 microns.)

(5) Flight paths should be oriented as nearly as possible into the wind when there is no tactical reason or advantage for crosswind delivery (*f*(2) below).

(6) Spray applications should not be made when it is raining or when rain is predicted.

f. Spray Drift.

(1) Spray drift from herbicide missions may be a problem when food crops of friendly personnel are near the target. Principal factors influencing drift distance are: droplet size, height of release, windspeed, and other atmospheric conditions. Under the worst delivery conditions, drift from herbicide spray should not cause damage to broad-leaved crops at distances greater than those listed in table 5–1. These distances include a buffer zone between the area being sprayed and crops.

(2) In general, drift hazard can be reduced in the following ways:

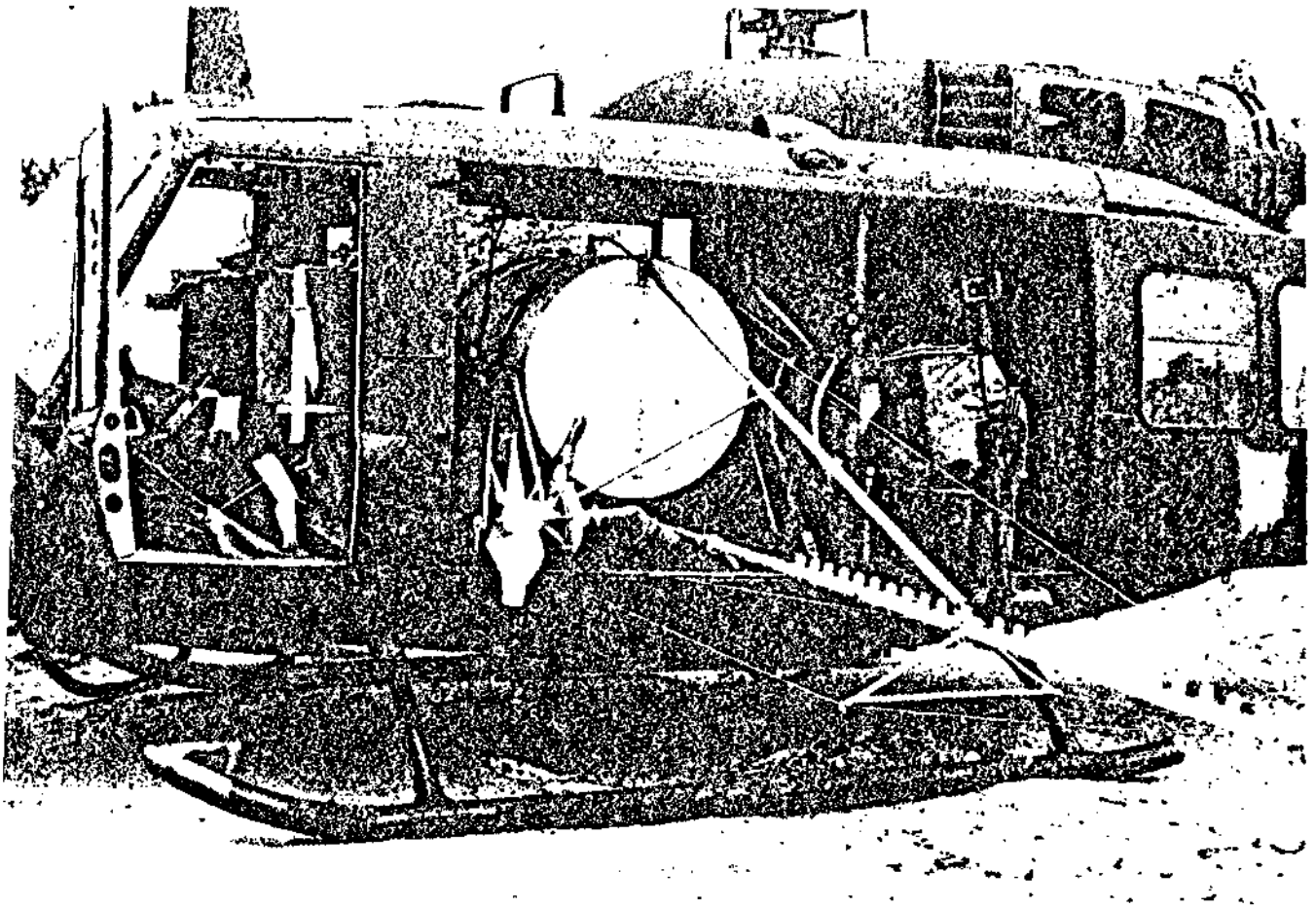


Figure 5-3. AGRINAUTICS spray system.

- Disseminate defoliants at lower altitudes.
- Deliver in the crosswind direction.
- Perform missions when the windspeed is low or the wind blows away from desirable vegetation.

Table 5-1. Downwind Drift Distance in Kilometers [1,2]

Release altitude (feet)	Average windspeed (knots)	Delivery system [3]		
		A/A45Y-1	PAU-7/B	AGRINAUTICS
50	8	----------	----------	2
50	16	----------	----------	3
75	8	6	----------	2
75	16	7	----------	3
100	8	7	7	4
100	16	8	9	5
150	8	7	8	----------
150	16	10	10	----------
200	8	----------	9	----------
200	16	----------	12	----------

[1] Measured from downwind edge of target.
[2] Crops should not be damaged at drift distances given in table.
[3] Delivery parameters:

	Aircraft speed (knots)	Flow rate (gal/min)	Length of swath (km)
A/A45Y-1	130	100-285	about 16
PAU-7/B	550	260	about 7.5
AGRINAUTICS	50	175	about 1

5-2. Ground Dissemination Systems

a. Power-Driven Decontamination Apparatus (PDDA).

(1) *Description.* The PDDA is a truck or trailer mounted, self-contained spray system and is intended for dissemination of decontaminating material. These units can also be used to disseminate herbicides. Several different PDDA models are available and all are adaptable for use on vegetation-control problems. Tank capacities of the different models vary from 200 to 400 or 600 gallons. The larger models have power-take-off driven pumps capable of delivering herbicides at the rate of 35 to 60 gallons per minute at pump pressures up to 800 pounds per square inch. Delivery is through two hoses with adjustable nozzles. (Refer to TM 3-4230-203-12 and TM 3-4230-209-12 for information on PDDAs.)

(2) *Use.* PDDA units can be used with herbicides to control vegetation on minefields, perimeter defenses, and roadsides. For local application of herbicides, BLUE and WHITE can be diluted with 2 gallons of agent in 50 gallons of water.

ORANGE can be mixed with diesel fuel at the rate of 5 gallons of agent to 50 gallons of diesel fuel. Applications can be made at volumes of 50 to 100 gallons of spray solution per acre as required to completely wet the foliage.

Caution: **After using the PDDA for herbicide operations, agent must be thoroughly removed from the tank, pumps, hoses, and nozzles. Failure to remove residual herbicide will result in damage to rubber seals, hoses, and pumps. Once the PDDA has been used for herbicide operations, it is no longer safe for carrying water for drinking or showering. The PDDA should be tagged with a warning note and a warning note entered in the decon's logbook.**

b. Hand-Operated Devices. Several hand-operated pump and pressure devices are available to disperse limited amounts of herbicide. Normal application is a 1:10 ratio of herbicide to diluting solution (water or diesel fuel). Since these devices are issued for insect control purposes, they must be thoroughly cleaned after being used to spray herbicides so that food crops or commercial plants will not be damaged when the device is again used to spray insecticide.

c. Field Expedients. Any combination of pumps and spray nozzles mounted on any vehicle that can transport these items and the herbicide to the site of application can be used as ground field expedients. These expedient systems can also be used to spray diesel fuel or other flammable substances to burn treated vegetation.

d. Guidelines for Using Ground Dissemination Systems. Using ground-based systems allows exact placement of herbicide on the target and minimizes downwind drift of agent. Applications should not be made if windspeed exceeds 10 knots, or if it is raining or rain is predicted. The major disadvantages of ground-based systems for spray application are: the target area must be occupied and controlled by friendly troops; the terrain must be traversable by spray apparatus; and current systems have only a limited standoff capability. A 500-meter buffer distance should be maintained to avoid damage to desirable vegetation near the target.

CHAPTER 6

STORAGE, HANDLING, AND METHODS OF DISPOSAL

6-1. Storage

a. Herbicides are delivered in 55-gallon steel drums marked with an identifying color band—ORANGE, BLUE, or WHITE. Drums may be stored in either a horizontal or vertical position. Under prolonged storage, stockpiles should be checked periodically to determine the condition of the containers; leaking or damaged drums should be removed. ORANGE, BLUE, and WHITE are stable chemicals with a storage life of several years. The chemicals may outlast their metal containers in prolonged storage.

Caution: **Drums that have contained herbicides MUST NOT be used to hold potable or agricultural water; preferably the drums should be destroyed or have holes punched in them.**

b. Loading pumps and hoses used to transfer herbicides from drums to storage or aircraft tanks should be kept clean and free of dirt or other foreign material that could clog or impair the aircraft spray system. Transfer equipment should be flushed thoroughly with water after each use or after changing from one chemical to another.

6-2. Handling and Methods of Disposal

a. ORANGE.

(1) *Handling.*

(*a*) ORANGE may be handled with ordinary sanitary precautions; however, this agent on skin or clothing or in the eyes should be removed promptly by rinsing copiously with clear water to prevent possible irritation. Contaminated clothing should be washed before reuse.

(*b*) Exposure of rubber or neoprene hose to ORANGE results in deterioration. Transfer hoses, pump seals, and other equipment parts subjected to continued contact with this chemical should be checked often for deterioration unless they have been made from resistant materials such as Teflon or Viton.

(2) *Methods of disposal.*

(*a*) Spillage or spray deposit on aircraft and painted surfaces should be removed as soon as possible by washing the surfaces with diesel fuel or other light petroleum oils and then rinsing them thoroughly with clear water.

(*b*) Loading and storage areas where ORANGE has been spilled repeatedly may be decontaminated by flushing them several times with diesel fuel. The used diesel fuel should be drained into settling basins or pits so that it will be incorporated into the soil and decomposed by the action of soil microorganisms and sunlight. If possible, heavily contaminated soils or settling basins should be deep-plowed to work the agent into the soil to aid in leaching, decomposition, or deactivation.

(*c*) Containers should be removed from loading areas frequently to avoid damage or hazard to nearby sensitive crops by concentrated vapors of the chemicals or by improper use of the empty containers in agricultural areas. Used containers and surplus quantities of ORANGE should be buried in deep pits at locations where there will be the least possibility of agent leaching into water supplies or cultivated crop areas.

b. BLUE.

(1) *Handling.*

(*a*) BLUE can be safely handled using ordinary sanitary precautions to avoid prolonged contact with skin or clothing. Spillage should be avoided but can be removed by liberal flushing with clear water.

(*b*) The formation of precipitate in some lots of agent BLUE has caused difficulties. Drums should be checked to insure that precipitate, if present, is not pumped into the spray system. BLUE should not be used in a spray system either before or after WHITE unless the tank and system have been thoroughly flushed with water. A mixture of these two agents results in the formation of a precipitate consisting of the sodium salt of 2,4-D (component of WHITE). When an agent is to be changed, the tanks or spray system should be filled at least half full with clean water and the system exhausted of liquid before the new agent is added.

(2) *Methods of disposal.*

(*a*) Equipment used to apply BLUE should be thoroughly cleaned before being stored or discarded. Several flushings with soap or detergent water to which ammonia has been added should be followed by a clear rinse. For most spray systems, a final rinse with diesel fuel may prevent the accumulation of rust or sediment.

(*b*) Excessive spillage of BLUE in loading or storage areas should be removed by a thorough washing with clear water and diluted ammonia. If possible, runoff or excess water containing diluted BLUE should be diverted into pits or settling basins for incorporation into soil. Used containers and residual chemicals should be buried whenever possible.

c. WHITE.

(1) *Handling.*

(*a*) Ordinary precautions used for any common argicultural chemical are recommended for handling WHITE. This agent may be mildly irritating to skin and eyes on prolonged contact, and spillage on the skin should be rinsed with clear water. Contaminated clothing should be washed before reuse.

(*b*) Tanks and spray systems should be thoroughly flushed with water before a period of disuse or before using agent BLUE (*b*(1) above).

(2) *Methods of disposal.*

(*a*) The picloram in WHITE is persistent in spray equipment, containers, and soil. Thus, full decontamination of equipment and areas subject to spillage is extremely difficult. A vigorous cleaning with soap and water, ammonia water, and clear rinses and flushings is necessary. Equipment used for WHITE should not be used for other purposes such as applying fertilizers or insecticides.

(*b*) Loading and storage areas subject to chemical spillage may be partially decontaminated by repeated washings with ammonia water and flushings with clear water. Runoff water from such flushings should be diverted into settling basins or restricted areas not likely to overflow onto crop land.

APPENDIX A

REFERENCES

A-1. Army Regulations (AR)

310-25	Dictionary of United States Army Terms (AD).
310-50	Authorized Abbreviations and Brevity Codes.

A-2. Field Manuals (FM)

3-1	Chemical, Biological and Radiological (CBR) Support.
33-5	Psychological Operations Techniques and Procedures.
41-10	Civil Affairs Operations.

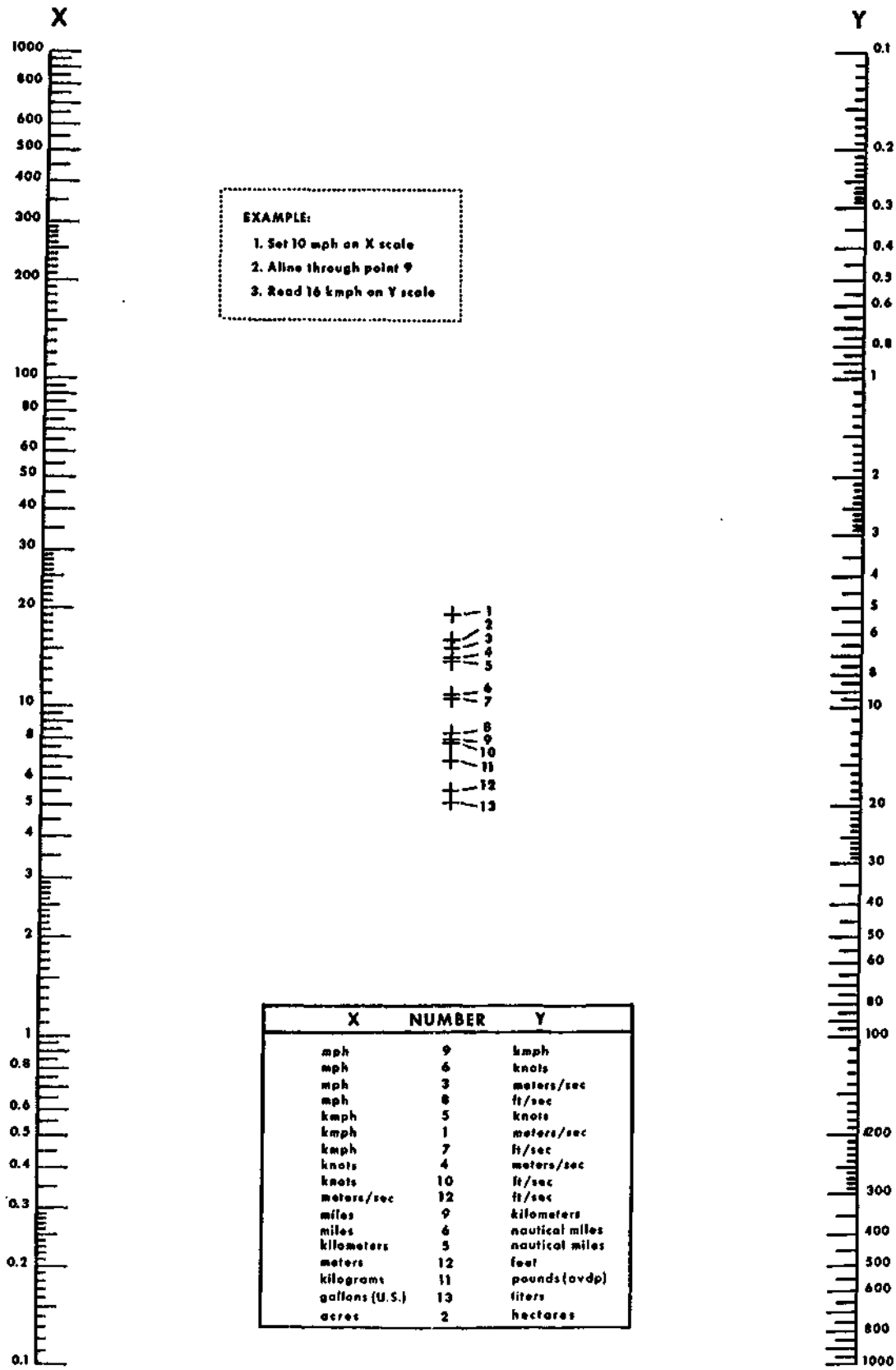
A-3. Technical Manuals (TM)

3-4230-203-12	Decontaminating Apparatus, Power-Driven, Truck Mounted, 400-Gallon, M9.
3-4230-209-12	Decontaminating Apparatus, Power-Driven, Skid-Mounted, Multipurpose, Nonintegral, 500-Gallon, M12A1.

A-4. Tables of Organization and Equipment (TOE)

3-500	Chemical Service Organization, Teams FB and PA.

APPENDIX B
CONVERSION CHART



X	NUMBER	Y
mph	9	kmph
mph	6	knots
mph	3	meters/sec
mph	8	ft/sec
kmph	5	knots
kmph	1	meters/sec
kmph	7	ft/sec
knots	4	meters/sec
knots	10	ft/sec
meters/sec	12	ft/sec
miles	9	kilometers
miles	6	nautical miles
kilometers	5	nautical miles
meters	12	feet
kilograms	11	pounds (avdp)
gallons (U.S.)	13	liters
acres	2	hectares

GLOSSARY

Canopy—The system of branches and leaves formed by woody plants at some distance above the ground.

Cereal crop—Plants from which grain is derived for human consumption (e.g., wheat, barley, oats, rye).

Conifer—Cone-bearing tree or shrub. Conifers are mostly evergreens such as pine or spruce.

Contact herbicide—A herbicide that kills or damages plant tissue at the point of application. It exhibits little or no movement within the plant.

Decomposition—The breaking down of a substance into other substances.

Defoliant—An agent which, when applied to plants, kills or damages them or causes them to shed their leaves.

Desiccant—A substance that has an affinity for water. When used as defoliants, desiccants remove water from plant tissue causing it to dry and shrivel.

Evergreen—A plant which bears and loses leaves continuously throughout the year.

Flash point—The lowest temperature at which a substance gives off enough combustible vapors to produce momentary ignition when a flame is applied under controlled conditions.

Foliage—The mass of leaves of plants.

Herbaceous plant—A soft, green plant that contains little woody tissue.

Inversion condition—The atmospheric condition in which the air temperature increases with increasing height above the ground. There are no natural convection currents; therefore, the atmosphere is stable and normally is considered to be the most favorable for agent dissemination.

Lapse condition—The atmospheric condition in which the air temperature decreases with increasing height above the ground. Strong convection currents are formed. This condition is unstable and normally is considered to be the most unfavorable for agent dissemination.

Leaching—The process whereby soluble components in the soil are dissolved out or filtered/diffused downward by water action, e.g., rainfall.

Mass median diameter—The diameter of the median particle size of a population of droplets.

Microogranism—An organism of microscopic or ultramicroscopic size.

Miscible—Capable of being mixed.

Monocotyledonous—Pertaining to a class of plants whose seeds have a single cotyledon (leaf formed directly from the seed). These plants are further characterized by leaves having parallel veins; the vascular bundles of the stems are scattered and closed.

Neutral condition—The atmospheric condition in which the ground temperature is approximately the same as that of the lower layers of air. This condition is considered satisfactory but not optimum for agent dissemination.

Nonvolatile—Not readily vaporized at normal temperatures.

Perennial plant—A plant living for several seasons and normally flowering and fruiting at least in the second and subsequent seasons.

Systemic herbicide—A herbicide that, after uptake through roots or foliage, moves within the plant affecting parts of the plant remote from the point of application.

Translocated herbicide—See systemic herbicide.

By Order of the Secretary of the Army:

W. C. WESTMORELAND,
General, United States Army,
Chief of Staff.

Official:
VERNE L. BOWERS,
Major General, United States Army,
The Adjutant General.

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